On the Soil Inhabiting Collembola (Insecta) and Oribatei (Acarina) of the Olderfjord Region of North Norway

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Twenty-seven Collembola and 53 Oribatei species were recorded in 264 soil samples from 5 localities of different vegetation types in the Olderfjord region of Norway, and extracted in a portable, modified Tullgren funnel extractor. Tables were prepared for total numbers of each species recorded in the samples, and the estimated abundance per m^2 of each species was compared with similar data from other arctic countries. There was close similarity in habitat choice, abundance and frequency of the Collembola between N Norway and elsewhere in the arctic. Relative abundance and frequency of the Oribatei were more varied than for the Collembola, but the densities of both groups were similar in order of magnitude in all localities, despite the greater number of species recorded in the former group.

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Several ecological studies have been made on the soil inhabiting microarthropods of arctic countries, including Canada (Hammer 1952, 1953a, 1955), Greenland (Hammer 1944, Strenske 1955), Jan Mayen (Macfadyen 1954), Iceland (Sellnick 1940, Tuxen 1943, Bödvarsson 1957), S Finland (Karpinnen 1955), N Sweden (Agrell 1941, Dalenius 1960), S Sweden (Dalenius 1950, Bödvarsson 1961). The only similar work conducted in arctic Norway, however, was by Lie-Pettersen (1906), and Agrell (1941) as part of his survey of N Sweden.

The present survey was conducted in the Olderfjord region of the Öksfjord peninsula, 250 miles north of the arctic circle (Fig. 1). The results of the survey include the first comprehensive species list of Collembola and Oribatei recovered by contemporary soil sampling techniques from this area of Norway.

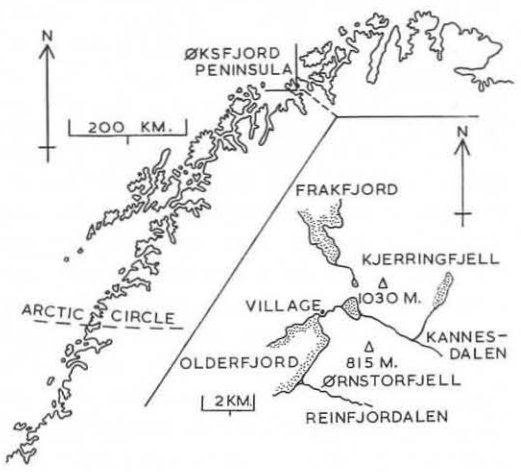

Fig. 1. North Norway showing Öksfjord Peninsula in relation to the Arctic Circle. Inset: Olderfjord Area.

Table I. Number of stations in which the Collembola species occur in the various abundance and frequency classes, total number of stations in which each species occurs, and total number of each species in the dry heath locality

Species	Abundance				Frequency			Total number of stations	Species total number
	Sol.	Sparse	Num.	Abund.	Cas.	Reg.	Con.		
Hypogastrura scotica	3	1			4			4	5
Friesea mirabilis	1	7	2	8	8	4	6	18	432
Anurida pygmaea	4	4			8			8	18
A. forsslundi	2	9	1		9	3		12	56
Neanura muscorum	2	2			4			4	6
Tullbergia krausbaueri	3	13	1	4	14	4	3	21	179
Onychiurus bicampatus	4	11			11	3	2	16	73
O. pseudovanderdrifti	2	16			8	9	1	18	74
Tetracanthella wahlgreni	1	3	2	6	4	5	3	12	255
Anurophorous binoculatus	3	7	1		9	2		11	55
Folsomia quadrioculata	3	4	2	13	5	8	9	22	1500
F. sensibilis	2	6			7	1		8	34
Isotomiella minor	1	10	3	4	7	9	2	18	250
Isotoma sensibilis		1				1		1	5
I. notabilis	1	5			6			6	18
I. viridis	4	9	1	4	14	1	3	18	227
I. arborea		1			1			1	5
Entomobrya nivalis	1				1			1	1
Lepidocyrtus curvicollis	1				1			1	1
L. cyaneus	1				1			1	1
Bourtiella repanda	1				1			1	1
Neelus minimus	5	4			8		1	9	19
Sminthurides sp.	1				1			1	1

In all tables, Sol.=solitary, Num.=numerous, and Abund.=abundant in the abundance class, whilst Cas.=casual, Reg.=regular, and Con.=constant in the frequency class referred to in the text

METHODS

During the course of the field work, from 13 July to 4 September 1961, 264 soil samples, each 25 $cm^2 \times 3$ cm, were collected by auger from 44 stations. Six replicate samples were collected at random from each sampling station, and placed in a portable soil-extractor designed specifically for the study. The extractor incorporated the main features of the small canister apparatus described by Macfadyen (1961). The field extractor differed from the laboratory type in that the electrically operated heater was replaced by an enclosed water tank, supplied with hot water by convection currents from a reservoir tank heated over a paraffin burner. The temperatures above and below the soil samples were kept as near as possible to those recorded by Macfadyen as producing maximum extraction.

Notes were made on the flora, soil type and depth of each station sampled. The scale of moisture content was estimated subjectively on impressions in the field, and is similar to that used by Bödvarsson (1957). The stations were classified as wet when water ran from the soil during sampling, and all drier soils of normal consistency were classified as dry.

The stations sampled were grouped in the following habitat types, which are henceforth referred to as localities:

a. Dry heath, composed of varying proportions of *Vaccinium vitis-idaea, V. uligino-*

Table II. Number of stations in which the Collembola species occur in the various abundance and frequency classes, total number of stations in which each species occurs aud total number of each species in the wet heath locality

Species	Abundance				Frequency			Total number of stations	Species total number
	Sol.	Sparse	Num.	Abund.	Cas.	Reg.	Con.		
Hypogastrura scotica		1				1		3	3
Friesea mirabilis	1	2			2	1		3	4
Anurida pygmaea	1				1			1	1
A. forsslundi	2				2			2	2
Tullbergia krausbaueri	2	1			3			3	4
Onychiurus bicampatus	1				1			1	1
O. pseudovanderdrifti		1			1			1	3
Tetracanthella wahlgreni	1				1			1	1
Folsomia quadrioculata	1	3	1		2	3		5	31
F. sensibilis		1			1			1	2
Isotomiella minor	2	1			2	1		3	11
Isotoma notabilis	1	1			1	1		2	9
I. viridis	3	1		1	3	2		5	67
Entomobrya nivalis	1				1			1	1
Neelus minimus	2				2			2	2
Sminthurides spp.	1	1			2			2	3

sum, V. myrtillus and *Empetrum nigrum*. (144 samples from 24 stations, Tables I and VIII)

b. Wet heath, composed as in a. above. (36 samples from 6 stations, Tables II and IX)

c. Hay meadow with *Rumex* sp. and *Poa* sp. (12 samples on 2 sampling occasions from the same station, and included under this locality heading, Tables III and X)

d. Humus in a birchwood. (12 samples on 2 sampling occasions, Tables IV and XI)

e. Mineral soil stations with a poor cover of *Cryptogramma crispa, Alchemilla alpina, Salix herbacea, S. reticulata, Silene acaulis* and *Dryas octopetala*. Stations with the latter two species, similar to Bödvarsson's 'fell field' (1957), were restricted to above 860 m in the area, and did not contain any ericaceous plants as found in *Dryas* heaths of other arctic countries and described by Hammer (1953b). (60 samples from 10 stations, Tables V and XII)

RESULTS

Owing to the low number of animals found in the relatively small soil samples, an arbitrary form of classification of abundance and frequency has been adopted and is not based on similar terms used in previous work. The following terms have been used in the text and tables:

Abundance (per unit of 6 samples from each station)

Abundant — more than 21 individuals present
Numerous — 11-20 individuals
Sparse — 2-10 individuals
Solitary — 1 individual

Frequency

Constant — 5-6 samples from a station
Regular — 3-4 samples
Casual — 1-2 samples

In the original study (Cadwalladr 1965) various forms of analyses such as 'differential' species (Macfadyen 1954) and correlation coefficients of association of species between stations

Table III. Number of stations in which the Collembola species occur in the various abundance and frequency classes, total number of stations in which each species occurs and the total number of each species in the hay meadow locality

Species	Abundance				Frequency			Total number of stations	Species total number
	Sol.	Sparse	Num.	Abund.	Cas.	Reg.	Con.		
Friesea mirabilis	1				1			1	1
Anurida pygmaea	1				1			1	1
Tullbergia krausbaueri		1		1	1	1		2	38
Onychiurus bicampatus		1	1		1		1	2	20
O. pseudovanderdrifti			2				2	2	31
Folsomia quadrioculata			1	1		1	1	2	56
F. sensibilis	2				2			2	2
Isotomiella minor	1			1	1	1		2	36
Isotoma notabilis		1			1			1	6
I. viridis		1				1		1	9
Isotomurus palustris			1			1		1	20
Entomobrya nivalis	1				1			1	1
Neelus minimus		1			1			1	3
Sminthurides spp.			1			1		1	17

Table IV. Number of stations in which the Collembola species occur in the various abundance and frequency classes, total number of stations in which each species occurs and total number of each species in the birchwood locality

Species	Abundance				Frequency			Total number of stations	Species total number
	Sol.	Sparse	Num.	Abund.	Cas.	Reg.	Con.		
Hypogastrura scotica	1				1			1	1
Friesea mirabilis		2			1	1		2	7
Anurida forsslundi		1			1			1	2
Neanura muscorum	1				1			1	1
Tullbergia krausbaueri		2			1	1		2	9
Onychiurus bicampatus		1				1		1	6
O. pseudovanderdrifti			1			1		1	14
Anurophorous binoculatus	1				1			1	1
Folsomia quadrioculata		1		1		1	1	2	72
Isotomiella minor	1			1	1		1	2	25
Isotoma sensibilis		1			1			1	2
I. notabilis	1	1			2			2	8
I. viridis	1			1	1	1		2	37
Lepidocyrtus curvicollis		1				1		1	5

Table V. Number of stations in which the Collembola species occur in the various abundance and frequency classes, total number of stations in which each species occurs and the total number of each species in the mineral soil locality

Species	Abundance				Frequency			Total number of stations	Species total number
	Sol.	Sparse	Num.	Abund.	Cas.	Reg.	Con.		
Hypogastrura scotica	1				1			1	1
Friesea mirabilis	3	2			5			5	8
Tullbergia krausbaueri	3	2		1	5	1		6	46
Onychiurus bicampatus	1	1			2			2	3
O. pseudovanderdrifti	1	2			2	1		3	6
Tetracanthella wahlgreni	2	2			2	2		4	15
Anurophorous binoculatus	1				1			1	1
Folsomia quadrioculata	2	5	1	1	3	5	1	9	122
Isotomiella minor	1	2			1	2		3	8
Isotoma notabilis	1				1			1	1
I. viridis	4				4			4	4
Neelus minimus	3				3			3	3
Sminthurides sp.	1				1			1	1

(Sörensen 1948), were used without success to distinguish faunal associations, in order to characterise the various stations. The failure to classify the stations into general localities on faunal characteristics was due to most species being recorded in the majority of stations sampled. The stations differed only in the number of species present and the abundance of these species, rather than in the kind of species present. The number and abundance of the species present in the stations is, on a subjective analysis of the data, clearly related to the moisture content, type of soil and vegetative cover. The results have therefore been presented according to these characteristics and grouped into 5 localities as described under Methods.

Collembola

The systematic order of the species in the following list is arranged according to Gisin (1960), and the notes on distribution of each species are based on the data in Tables I—V. Notes have also been included for some species as previously described for N Norway by Lie-Pettersen (1906) and Agrell (1941).

1. *Hypogastrura scotica* (Carpenter and Evans)
   Found in very small numbers in all localities, except for the hay meadow where it is absent. Nearly always solitary and casual.
2. *Friesea mirabilis* (Tullberg)
   One of the most common species present, but is abundant and constant only in dry heath. It is found in fewer numbers and lower frequency in other localities.
3. *Anurida pygmaea* (Björner), syn. *Micranurida pygmaea* Börner
   Solitary to sparse and casual in dry heath, and solitary and casual in wet heath and hay meadow.
4. *Anurida alpina* (Agrell)
   One specimen found in the *A. pygmaea* material. Locality unknown. Agrell (1941) found this species in Beisfjordstötta at 1448 m in *Polytrichum* and *Dicranum* moss (15 individuals/400 cm^3).
5. *A. forsslundi* (Gisin)

Most commonly sparse and casual in dry heath and birchwood, but solitary and casual in wet heath, and absent from the hay meadow and mineral soil localities.

6. *Neanura muscorum* (Templeton)
Found only in 5 stations, solitary and casual in one sample from the birchwood, and solitary to sparse and casual in 4 stations in the dry heath locality. Lie-Pettersen (1906) found the species in rotting wood in a birchwood near Tromsö.
7. *Tullbergia krausbaueri* (Börner)
One of the most abundant species recorded, although abundant and constant only in the dry heath locality. Otherwise abundant with lower frequency in mineral soil stations and in the hay meadow. The species is found in low numbers and frequency in the other two localities.
8. *Onychiurus bicampatus* Gisin
Generally sparse and casual in most localities, but numerous and constant in the hay meadow.
9. *O. pseudovanderdrifti* Gisin
Similar in distribution to *O. bicampatus*, although generally in slightly higher numbers. This similarity may in part be accounted for by the difficulty encountered in distinguishing between juveniles of this species and adults of *O. bicampatus*. Both species are already known from Iceland and the Faroes, and Gisin (pers. comm.) suggests that finding both species at Olderfjord, far removed from the former areas, confirms the validity of the species.
10. *O. arcticus* (Tullberg)
This large species, which is confined to the Arctic, was found only under rotting seaweed in the inter-tidal zone. The species was extremely abundant, and was found to cover the rocks when the sea-weed was removed. Agrell (1941) found this species in abundance in damp moss in Beisfjordstötta.
11. *Tetracanthella wahlgreni* Linnaniemi
Constant and abundant only in dry heath, but most commonly sparse and regular or solitary and casual in this locality and the wet heath and mineral soil localities. Absent from the hay meadow and birchwood.
12. *Anurophorous binoculatus* (Kseneman), syn. *Pseudanurophorous binoculatus* Kseneman
Solitary to sparse and casual to regular in dry heath, and solitary and casual in mineral soil samples and in the birchwood. Absent from the other two localities.
13. *Folsomia quadrioculata* (Tullberg), syn. *Isotoma quadrioculata* Tullberg
The most common species recorded, found in all but one of the stations sampled, and in over 50 % of the samples taken. Abundant and constant in all localities, except for the wet heath locality where it is numerous. Lie-Pettersen (1906) records the species as abundant.
14. *F. sensibilis* Kseneman
Found only in dry heath stations, where it is mainly sparse and casual, and only in those stations where *F. quadrioculata* is very abundant.
15. *Isotomiella minor* (Schäffer), syn. *Isotoma minor* Schäffer
Sparse to abundant, but mainly the latter, and casual to regular in dry heath, and solitary and casual in the other localities, except the mineral soil stations where it is absent.
16. *Isotoma sensibilis* (Tullberg), syn. *Pseudisotoma sensibilis* Tullberg
Five specimens recorded in 3 samples from a dry heath station. Lie-Pettersen (1906) records this species as common in moss and lichen, and widely distributed in S Norway.
17. *I. notabilis* Schäffer
Sparse and casual in dry heath, generally solitary and casual in other localities.
18. *I. viridis* Bourlet
Abundant and constant only in dry heath, and abundant and regular in birchwood, but mainly sparse and casual in these two localities as it is in the other localities. It is recorded by Lie-Pettersen (1906) as one of the most common species present.
19. *I. arborea* (Linné)

Five specimens in one sample in one of the dry heath stations.

20. *Isotomurus palustris* (Müller)
Found only in the hay meadow, where 20 specimens were found in 3 samples. Lie-Pettersen (1906) records the species as common on the sides and surfaces of bog pools.
21. *Entomobrya nivalis* (Linné)
Solitary in one sample each from dry and wet heath, and the hay meadow. One of the least abundant species recorded.
22. *Lepidocyrtus curvicollis* Bourlet
Solitary and casual in dry heath, and sparse and regular in birchwoods. Absent from the other localities. One of the least abundant species recorded.
23. *L. cyaneus* Tullberg
One specimen in one sample from a dry heath station. Similarly, Lie-Pettersen (1906) records only one specimen.
24. *Bourtiella repanda* (Agren)
One male specimen in a sample from a dry heath station.
25. *Neelus minimus* Willem
Solitary to sparse and casual to regular, but mainly casual, in dry heath. Generally solitary and casual in the other localities, but absent from the birchwood.
26. *Sminthurides pumilis* (Krausbauer), syn. *Sphaeridio pumilio* Krausbauer
This species was grouped with the following *S. parvulus*.
27. *S. parvulus* (Krausbauer)
Sparse and casual in dry heath, numerous and regular in the hay meadow and generally solitary and casual in the other localities.

Arctic bio-geography and ecology of the Collembola

The Collembola, with specialized body form and ecological requirements, are restricted to certain habitats having optimum conditions for their survival. A comparison of the ecology of the Collembola recorded for Olderfjord with that in other arctic countries and adjacent areas, as published in the literature listed in the introduction, reveals a great similarity in habitat choice, abundance and frequency. NW Norway is subject to relatively heavy rainfall during the summer months so that the majority of localities, if not saturated with water, probably have a relative humidity of 100 %. An arbitrary scale of soil moisture content is used in the present study, and it is probable that the localities described as dry are only relatively so, and are comparable with the wet habitats described elsewhere.

Anurida pygmaea, Anurophorous binoculatus and *Folsomia sensibilis,* all small unpigmented species, are nearly always found in low numbers and low frequency in dry heath vegetation. *Neanura muscorum* has a similar distribution. Other species such as *Tullbergia krausbaueri* and *Tetracanthella wahlgreni* are found in the same habitat but in higher numbers, although Hammer (1953b) recorded the former species as common in dripping wet *Sphagnum* in Canada. *Isotoma sensibilis* is generally confined to moss, and the *Smithurides* spp., recorded as numerous and regular in the hay meadow at Olderfjord, have been described as being confined to meadows and grassy localities in Iceland and S Sweden. *Folsomia quadrioculata* is dominant and ubiquitous in Norway, Greenland and Canada, yet in Iceland, even though it is ubiquitous, it is never found in high numbers and is very rarely constant. This species has not been recorded for Jan Mayen, which is surprising considering its widespread choice of habitats in other arctic countries. The species appears to be replaced by *F. sexoculata* on the island. *Isotomiella minor,* another widely distributed species, is also one of the most common species found in N Norway and S Sweden, but is always found in low numbers in Iceland and has a restricted distribution on Jan Mayen. As well as being recorded as common in S Sweden, it is also described as ubiquitous. *Isotoma notabilis* is another common and ubiquitous species. It is recorded in 72.7 % of all localities in Iceland, 67 % in Olderfjord, in 33.3 % of all soil samples taken by Bödvars-

Table VI. Number of Collembola species recorded for Olderfjord represented in the faunas of other arctic countries

Family	Older-fjord	Canada	Green-land	Jan Mayen	Iceland	Lapland	Torne-träsk	South Sweden
Poduridae	6	1	1	1	3	1	4	3
Onychiuridae	4	–	1	2	1	–	1	1
Isotomidae	10	5	6	6	7	3	7	7
Entomobryidae	3	–	1	–	2	2	1	2
Sminthuridae	3	–	–	2	1	–	1	1
Total	26	6	9	11	14	6	14	14

son in S Sweden, and is common in Greenland and Canada. The species is also recorded as ubiquitous on Jan Mayen. *Entomobrya nivalis,* recorded as abundant in Iceland, was recorded as one of the least abundant species in Olderfjord. This difference in abundance, however, may be due to the collection technique rather than to any geographical or ecological reasons. Bödvarsson (1957) suggested this as an explanation for the difference between the low numbers of *E. nivalis* he recorded for Iceland and the higher numbers recorded in an earlier study in the country. A further reason for this difference in abundance, is that it may be the result of the sampling of the population at different times in its seasonal cycle. This species

Table VII. Mean numbers per m² of the Collembola species in the five localities

Species	Dry heath	Hay meadow	Birchwood	Mineral soil	Wet heath
Hypogastrura scotica	14		33	7	33
Friesea mirabilis	1200	33	233	53	44
Anurida pygmaea	50	33			11
A. forsslundi	156		67		22
Neanura muscorum	17		33		
Tullbergia krausbaueri	497	1267	300	307	44
Onychiurus bicampatus	203	667	200	20	11
O. pseudovanderdrifti	206	1033	467	40	33
Tetracanthella wahlgreni	708			100	11
Anurophorous binoculatus	153		33	7	
Folsomia quadrioculata	4167	1867	2400	813	344
F. sensibilis	94	67			22
Isotomiella minor	694	1200	833	53	122
Isotoma sensibilis	14		67		
I. notabilis	50	200	267	7	100
I. viridis	631	300	1233	27	744
I. arborea	14				
Isotomurus palustris		667			
Entomobrya nivalis	3	33			11
Lepidocyrtus curvicollis	3		167		
L. cyaneus	3				
Bourtiella repanda	3				
Neelus minimus	53	100		20	22
Sminthurides spp.	3	567		7	33

Table VIII. Number of stations in which the Oribatei species occur in the various abundance and frequency classes, total number of stations in which each species occurs and total number of each species in the dry heath locality

Species	Abundance				Frequency			Total number of stations	Species total number
	Sol.	Sparse	Num.	Abund.	Cas.	Reg.	Con.		
Eulohmannia ribiagi	3	6	2	2	7	3	3	13	119
Nanhermannia nana	2	1		1	3		1	4	74
Brachychthonius spp.		6	1	10	7	5	5	17	1 203
Synchthonius boschmai	2	9	1	7	8	5	6	19	378
Platynothrus thori	1	3			2	2		4	10
P. peltifer	4	1			5			5	7
Camisia lapponica		2			2			2	6
C. spinifer	2	2			4			4	6
C. segnis	3	8	1		8	3	1	12	58
Heminothrus paolianus	4	2			6			6	9
Nothrus palustris	3	6	1		9	1		9	39
N. borussicus	5	3			7	1		8	20
Hermannia reticulata	1	1			2			2	4
Caleremaeus monilepes	1	1			2			2	3
Belba compta	5	6			8	3		11	70
Suctobelba perforata	2	7	2		7	3	1	11	64
S. longirostris	2	5	1		6	2		8	45
Oppia translamellata	3	8	2		10	1	2	13	72
O. ornata	2	5			7			7	19
O. quadricarinata		1			1			1	9
O. neerlandica	2		1		2	1		3	14
O. subpectinata	3	5	3	3	4	5	5	14	137
Oribella castanea		1			1			1	3
Ceratoppia sphaerica		1			1			1	2
Tectocepheus velatus	3	4	1	9	7	4	6	17	985
Carabodes marginatus	2	6	1	1	6	3	1	10	76
Liebstadia similis	2	4			6			6	20
Oribatula venusta		19			13	5	1	19	82
Liacarus coracinus	5	7			11	1		12	26
Adoristes ovatus	4	5	2		5	3	3	11	64
Chamobates borealis	2				2			2	2
Melanozetes mollicomus		6	1	1	4	3	1	8	71
Neoribates aurantiacus	2	2			4			4	8
Edwardzetes edwardsii	1				1			1	1
Calyptozetes sarakensis	1				1			1	1
Pelops spp.	5	1			6			6	7
Achipteria coleopterata	1	1			2			2	9
A. punctata	4	5	1		7	3		10	37
A. italicus	2	4	3		4	2	3	9	87
Oromurcia bicuspidata	3	1			3	1		4	7
Phthiracarus piger	4	12			14	2		16	42
P. borealis	3	7	1	2	6	5	2	13	103
Hoploderma striculum	3	2			4	1		5	11
Oribotritia loricata		3	1		1	3		4	27

Table IX. Number of stations in which the Oribatei species occur in the various abundance and frequency classes, total number of stations in which each species occurs and total number of each species in the wet heath locality

Species	Abundance				Frequency			Total number of stations	Species total number
	Sol.	Sparse	Num.	Abund.	Cas.	Reg.	Con.		
Nanhermannia nana	1				1			1	1
Hypochthonius rufulus	1				1			1	1
Brachychthonius sp.	1				1			1	1
Synchthonius boschmai	3	1			4			4	6
Platynothrus thori	1				1			1	1
P. peltifer	2				2			2	2
Camisia segnis	2				2			2	2
Nothrus palustris	1				1			1	1
N. borussicus	1	1	1		2	1		3	14
Suctobelba longirostris	2				2			2	2
Oppia translamellata	1				1			1	1
O. neerlandica	1				1			1	1
O. subpectinata	1	2			3			3	9
Tectocepheus velatus		2			1	1		2	8
Carabodes marginatus	1	2			3			3	8
Oribatula venusta	1	1			1	1		2	7
Liacarus coracinus	1	2			2	1		3	6
Melanozetes mollicomus	1	4			5			5	11
Pelops spp.	1	1			2			2	3
Achipteria coleopterata		1			1			1	6
Phthiracarus piger	2	2			4			4	6
P. borealis		1			1			1	8
Hoploderma striculum	2				2			2	2

lives on the larger vegetation rather than in the soil, and was probably not collected in samples removed from the soil. Similarly, the large number of juveniles rather than adults of *Isotoma viridis* for Olderfjord may be due to these reasons. *Onychiurus arcticus* and *Anurida alpina* are distinct in that they are restricted in distribution to the arctic zone.

It is recognized by several authors, including Hammer (1944) and Bödvarsson (1957) that the higher forms of Collembola in the family Entomobryidae, are less resistant to extreme conditions than are members of the other three families. Tables VI and VII show that the Entomobryidae are poorly represented in arctic countries, none being recorded for Jan Mayen.

Relative density of the Collembola

The density of Collembola species per m^2 given in Table VII is estimated as the mean for all samples, e.g. 144 samples from the dry heath locality, irrespective of whether individual species occur in less than the total number of samples taken from the stations in that locality. The densities would of course be higher if the means are estimated for only those samples in a locality in which the species occur. This is also applicable to the densities of Oribatei given in Table XIII.

Of the 24 species listed in Table VII, most (11) are recorded in greatest density in the dry heath locality, followed by 9 species in the hay meadow, 5 species in the birchwood, and none in the mineral soil and wet heath.

Table X. Number of stations in which the Oribatei species occur in the various abundance and frequency classes, total number of stations in which each species occurs and total number of each species in the hay meadow locality

Species	Abundance				Frequency			Total number of stations	Species total number
	Sol.	Sparse	Num.	Abund.	Cas.	Reg.	Con.		
Synchthonius boschmai		1			1			1	5
Platynothrus peltifer		1		1	1		1	1	35
Nothrus palustris	1				1			1	1
Belba compta	1				1			1	1
Suctobelba perforata		1			1			1	4
Oppia translamellata	1				1			1	1
O. ornata		1			1			1	3
O. subpectinata		1			1			1	4
Tectocepheus velatus			1	1		2		1	47
Carabodes marginatus		1			1			1	10
Liebstadia similis		1	1		1	1		2	23
Oribatula venusta	2				2			2	2
Pelops sp.	1				1			1	1
Achipteria coleopterata		1			1			1	9
Oromurcia bicuspidata			2		1	1		2	34

Folsomia quadrioculata is the most abundant species recorded in terms of density and total numbers, and it is found in greatest numbers in the dry heath locality.

Oribatei

The systematic order of the species in the following list is arranged according to Willmann (1931), and the notes following each species refer to Tables VIII—XIII.

1. *Eulohmannia ribiagi* (Berlese)
   Solitary to sparse and casual in the dry heath locality, and solitary and casual in one sample each in the birchwood and the mineral soil locality. Absent from the wet heath and hay meadow localities.
2. *Nanhermannia nana* (Nicolet)
   Solitary to abundant and casual to constant in dry heath, and solitary and casual in one sample each in the wet heath locality and birchwood. Absent from the hay meadow and mineral soil localities.
3. *Hypochthonius rufulus* C. L. Koch
   One specimen in one sample each from a mineral soil and a wet heath station.
4. *Brachychthonius perpusillus* Berlese
5. *B. zelawaiensis* Sellnick
6. *B. semiornatus* G. O. Evans
   Owing to the difficulty in distinguishing between the three very small *Brachychthonius* species, the species were grouped together for a total count in the samples in which they occurred. In one sample taken from a dry heath station containing *Vaccinium uliginosum* and *Empetrum nigrum*, however, of 40 specimens recorded, 26 were *B. zelawaiensis* and 14 *B. semiornatus*. The genus as a group were sparse to abundant but never solitary, and casual to constant in the dry heath locality. The genus was not recorded in the hay meadow, and was poorly represented in the other localities.
7. *Synchthonius boschmai* van der Hammen
   Abundant and constant in more dry heath stations than the *Brachythonius spp.*, but generally in lower numbers. Mainly solitary to sparse and casual to regular in the other localities, but absent from the birchwood.

Table XI. Number of stations in which the Oribatei species occur in the various abundance and frequency classes, total number of stations in which each species occurs and total number of each species in the birchwood locality

Species	Abundance				Frequency			Total number of stations	Species total number
	Sol.	Sparse	Num.	Abund.	Cas.	Reg.	Con.		
Eulohmannia ribiagi	1				1			1	1
Nanhermannia nana	1				1			1	1
Brachychthonius spp.		1			1			1	3
Synchtonius boschmai	1	1			2			2	4
Platynothrus thori		1			1			1	10
P. peltifer	1				1			1	1
Camisia lapponica		1			1			1	3
Heminothrus paolianus		1			1			1	2
Nothrus borussicus		1			1			1	3
Damaeus tecticola		1			1			1	3
Suctobelba perforata	1				1			1	1
Oppia translamellata		1			1			1	4
O. quadricarinata	1			1	1		1	2	93
O. subpectinata		1		1	1		1	2	53
Tectocepheus velatus		1	1		1	1		2	15
Liebstadia similis		1				1		1	15
Oribatula venusta		2					2	2	13
Adoristes ovatus		2			1	1		2	9
Chamobates borealis		2			1	1		2	12
Ceratozetes thienemanni		2			2			2	6
Oromurcia bicuspidata		1			1			1	2
Phthiracarus piger	1	1			2			2	3

8. *Platynothrus thori* Berlese
   Sparse and casual to regular in wet heath, and one specimen in one sample each from the wet heath and birchwood localities.
9. *P. peltifer* (C. L. Koch)
   Solitary and casual in the dry heath, wet heath and birchwood localities. Abundant and constant only in the hay meadow, and sparse and regular only in the mineral soil locality.
10. *Camisia lapponica* (Trägårdh)
    Sparse and casual in the dry heath locality and birchwood, and absent from the other localities.
11. *C. spinifer* (C. L. Koch)
    Found only in the dry heath locality where it is solitary to sparse and casual.
12. *C. segnis* Hermann, syn. *C. bicarinata* (C. L. Koch)
    Regular and constant only in the dry heath locality, where it is mainly sparse and casual. Solitary and casual in the wet heath and mineral soil localities, and absent from the hay meadow and birchwood.
13. *Heminothrus paolianus* Berlese var. *longisetosus* Willmann
    Solitary to sparse and casual in the dry heath locality, and sparse and casual in the birchwood. Absent from the other localities.
14. *Nothrus palustris* (C. L. Koch)
    Solitary to numerous but mainly sparse, and casual to regular in the wet heath locality, and solitary and numerous, and casual and regular in the mineral soil locality. Solitary and sparse in the wet heath and hay meadow localities. Absent from the birchwood.

Table XII. Number of stations in which the Oribatei species occur in the various abundance and frequency classes, total number of stations in which each species occurs and the total number of each species in the mineral soil locality

Species	Abundance				Frequency			Total number of stations	Species total number
	Sol.	Sparse	Num.	Abund.	Cas.	Reg.	Con.		
Eulohmannia ribiagi	1				1			1	1
Hypochthonius rufulus	1				1			1	1
Brachychthonius spp.	2	1	1		4			4	26
Synchthonius boschmai	1	3			2	2		4	16
Platynothrus peltifer	1	2			1	2		3	20
Camisia segnis	1				1			1	1
Nothrus palustris	1		1		1	1		2	15
N. borussicus		1	1		1	1		2	18
Caleremaeus monilepes	1				1			1	1
Belba compta	1	1			1	1		2	4
Suctobelba longirostris	1				1			1	1
Oppia translamellata			1		1			1	12
O. neerlandica	1	1			2			2	3
O. subpectinata	1				1			1	1
Scutovortex bidactylus	1				1			1	1
Tectocepheus velatus	1				1			1	1
Carabodes marginatus	2	1			2	1		3	5
Liebstadia similis	2				2			2	2
Oribatula venusta	2			1	2	1		3	28
Liacarus coracinus		2	1		2	1		3	25
Adoristes ovatus		1			1			1	2
Melanozetes mollicomus	1				1			1	1
Calyptozetes sarakensis	1				1			1	1
Pelops spp.	3				3			3	3
Phthiracarus piger	3	1			4			4	6

15. *N. borussicus* Sellnick
Numerous and regular in the wet heath and mineral soil localities, sparse and casual in birchwood, and mainly solitary and casual in the dry heath locality.
16. *Hermannia reticulata* Thorell
Solitary to sparse and casual in the dry heath locality, absent from the other localities. One of the least abundant species recorded.
17. *Caleremaeus monilepes* (Michael)
Solitary to sparse and casual in the dry heath locality, and one specimen in one sample from a mineral soil sample. Very few specimens recorded.
18. *Belba compta* (Kulcz.)
Solitary to sparse and casual to regular in the dry heath and mineral soil localities. One specimen in one sample from the hay meadow.
19. *Damaeus tecticola* Michael
Recorded only in the birchwood, where it is sparse and casual.
20. *Suctobelba perforata* (Strenske)
Abundant in one station in the dry heath locality, where it is generally sparse and casual as it is in the hay meadow. Solitary and casual in the birchwood, and absent from the wet heath and mineral soil localities.

21. *S. longirostris* Forsslund
Mainly sparse and casual in the dry heath locality, and two specimens in two wet heath samples, and one specimen in a mineral soil sample.
22. *Oppia translamellata* (Willmann)
Constant and numerous only in the wet heath locality, where it is mainly sparse and casual as it is in the birchwood. Numerous and casual in one mineral soil station, and solitary and casual in the hay meadow and wet heath localities.
23. *O. ornata* (Oudemans)
Sparse and casual in the dry heath and hay meadow localities, and absent from the other localities.
24. *O. quadricarinata* (Michael)
Abundant and constant only in the birchwood, and sparse and regular in the dry heath localities. Absent from the other localities.
25. *O. neerlandica* (Oudemans) sensu Willmann (1931), syn. *O. nova* van der Hammen
Solitary and numerous, and casual to regular in the dry heath locality, and solitary to sparse and casual in the mineral soil locality. One specimen in a sample from a wet heath station.
26. *O. subpectinata* (Oudemans)
Solitary to abundant and casual to constant in the dry heath locality, and also abundant and constant in a birchwood station. Sparse and casual in the hay meadow, and solitary and casual in the wet heath and mineral soil localities. This is the only *Oppia* species to be recorded in all localities.
27. *Oribella castanea* (Hermann)
Sparse and casual in two dry heath stations. Absent elsewhere.
28. *Ceratoppia sphaerica* C. L. Koch
Two specimens in a sample from a dry heath station.
29. *Scutovortex bidactylus* Coggi
One specimen in a sample taken from a cushion of *Silene acaulis* in a mineral soil station.
30. *Tectocepheus velatus* (Michael)
One of the most abundant species recorded. Solitary to abundant and casual to constant in the dry heath locality, otherwise it is poorly represented in the other localities. It is, however, abundant and regular in the hay meadow.
31. *Carabodes marginatus* (Michael)
Solitary to abundant and casual to constant, but mainly sparse and casual in the dry heath locality. Generally sparse and casual in the other localities, except for the birchwood where it is abundant.
32. *Liebstadia similis* (Michael)
Several specimens examined lacked the process on Tibia I, and Dalenius (pers. comm.) considers this may be a new subspecies. Numerous and regular only in the hay meadow, and sparse and regular in the birchwood. Mainly sparse and casual in the dry heath locality, and solitary and casual in the mineral soil locality. Absent from wet heath.
33. *Oribatula venusta* Berlese, syn. *O. tibialis* (Nicolet) sensu Willmann (1931)
Abundant only in the mineral soil locality, where it is mainly solitary and casual, as it is in the hay meadow. Sparse but constant in the birchwood, and sparse and casual to constant in the dry heath locality. Solitary to sparse and casual to regular in the wet heath locality.
34. *Liacarus coracinus* (C. L. Koch)
Generally solitary to sparse and casual to regular in the dry and wet heath and mineral soil localities, but also numerous in the latter locality. Absent from the birchwood and hay meadow.
35. *Adoristes ovatus* (C. L. Koch)
Solitary to abundant and casual to constant only in the dry heath locality, and sparse and casual in the birchwood and mineral soil localities. Absent from the other localities.
36. *Scheloribates pallidulus* (C. L. Koch)
One specimen collected, locality unknown.
37. *Chamobates borealis (Trägårdh)*, syn. *C. schutzii* sensu Willmann (1931)

Solitary and casual in two stations in the dry heath locality, and sparse and casual to regular in the birchwood. Absent elsewhere.

38. *Ceratozetes thienemanni* Willmann
Sparse and casual in the birchwood, and absent elsewhere.
39. *Fuscozetes fuscipes* (C. L. Koch)
One specimen collected, locality unknown.
40. *Melanozetes mollicomus* (C. L. Koch)
Abundant and constant only in the dry heath locality, where it is mainly sparse and casual to regular. Sparse and casual in the wet heath locality, and one specimen in a sample from a mineral soil station. Absent from the birchwood and hay meadow.
41. *Neoribates aurantiacus* (Oudemans)
Solitary to sparse and casual in four dry heath stations, and absent from all other localities.
42. *Edwardzetes edwardsii* (Nicolet)
One specimen only in a sample from a dry heath station.
43. *Calyptozetes sarakensis* (Trägårdh)
One specimen in one sample each from the dry heath and mineral soil localities.
44. *Pelops planicornis* (Schrank)
45. *P. acronis* Hermann
This species and *P. planicornis* were difficult to distinguish apart at the working magnification. They are mainly solitary and always casual in all localities, except for the birchwood where they were absent.
46. *Achipteria coleopterata* (Linné)
Solitary to sparse and casual in the dry heath locality, and sparse and casual in the wet heath and hay meadow localities. Absent from the birchwood and the mineral soil localities.
47. *A. punctata* (Nicolet)
Found only in the dry heath locality where it is solitary to sparse and mainly casual.
48. *A. italicus* Oudemans, syn. *A. willmanni* van der Hammen
Abundant and constant in three dry heath stations, but mainly sparse and casual in this locality. Absent from the other localities.
It is of interest to note that none of the *Achipteria* species and the closely related *Pelops* species were recorded in the birchwood locality.
49. *Oromurcia bicuspidata* (Thor)
Solitary to sparse and casual to regular in the dry heath locality, and numerous and casual to regular in the hay meadow. It is constant only in the birchwood, where it is sparse.
50. *Phthiracarus piger* (Scopoli)
Solitary to abundant, but not numerous, and casual to regular in the dry heath locality, and solitary to sparse in the wet heath, birchwood and mineral soil localities. Absent from the hay meadow.
51. *P. borealis* (Trägårdh)
Numerous to abundant and regular to constant only in the dry heath locality, otherwise solitary to sparse and casual in the wet heath locality. Absent from the other localities.
52. *Hoploderma striculum* (C. L. Koch)
Solitary to sparse and mainly casual in the dry heath, and absent from the other localities.
53. *Oribotritia loricata* (Rathke)
Mainly sparse and casual in the dry heath locality, and absent from the other localities.

Several immature Oribatei were recorded in some stations, particularly in those in the dry heath locality. These have been identified as the nymphs of *Melanozetes* sp. *and Fuscozetes* sp. It is of interest to note that the nymphs of *Melanozetes* sp. fitted the description of *Alphypochthonius alpina* nov. gen., nov. sp. described by Schweizer (1956).

Arctic bio-geography and ecology of the Oribatei

Relative abundance and frequency of the Oribatei of Olderfjord and other arctic countries are far more varied than for the Collembola. In addition, the distribution of the Ori-

batei appears to be more dependent upon the moisture content of the soil.

One of the most dominant and abundant Oribatei in arctic countries is *Platynothrus peltifer,* which prefers damp localities. In Olderfjord it was one of the less abundant species, and was only recorded as abundant and constant in the hay meadow locality, the soil of which was damper than that of the other localities except for the wet heath locality. The most abundant species recorded for Olderfjord were *Synchthonius boschmai* and the *Brachychthonius* spp., which, whilst only abundant and constant as well as dominant in dry heath stations, were found in relatively high numbers and frequency in all other localities. *Brachychthonius semiornatus* has been recorded before only for England (Evans 1952), and *S. boschmai* for Holland (van der Hammen 1954), which would indicate that both are northern species for which these two countries mark the southernmost boundary of their distribution. *Tectocepheus velatus* is a common and ubiquitous species in all arctic and N European countries, whilst *Achipteria coleopterata* although found in low numbers, is also widely distributed.

Several species are restricted to specific habitats. *Platynothrus thori* is usually found in low numbers in damp habitats, whilst *Eulohmannia ribiagi, Suctobelba* spp., *Oppia ornata, Carabodes marginatus, Liacarus coracinus* and *Adoristes ovatus* are restricted to dry heaths, with varying relative abundance in the various countries. *Neoribates aurantiacus* is always found in low numbers in heath, whilst *Camisia spinifer* and *C. lapponica* are found in low numbers in a variety of habitats. The latter species is a northern species, with central Sweden marking the southerly limit of its distribution (Tarras-Wahlberg 1962).

Only one specimen of *Hypochthonius rufulus* was recorded in Olderfjord, otherwise the species is common in Canada where it is generally found in low numbers in damp localities. Other species such as *Oppia* spp., *Suctobelba longirostris, Oribatula venusta* and *Liebstadia similis* are found in varied numbers and localities in other countries. *Phthiracarus piger* is recorded in birchwoods in some arctic countries, and *P. borealis,* although found in low numbers in several localities in Olderfjord, is rare in other arctic countries, whilst *Scutovortex bidactylus* is not found elsewhere.

Of the 53 species recorded for N Norway the following numbers have been recorded in other arctic countries:

Torneträsk	31	Greenland	21
S Sweden	26	S Finland	15
Iceland	22	Jan Mayen	8
Canada	21		

Relative density of the Oribatei

The densities of the Oribatei species in the 5 localities in Table XIII are estimated in the same way as for the Collembola as described earlier.

Whilst the Oribatei are similar to the Collembola in that the majority of species are recorded in the dry heath locality, more species, 51 %, of the Oribatei are recorded in this locality, compared with 40 % of the Collembola. Of the 48 species listed in Table XIII, 27 species are recorded in the greatest density in the dry heath locality, 9 in the birchwood, 7 in the hay meadow, 4 in the mineral soil, and 1 in the wet heath locality. Whilst more Oribatei than Collembola species are recorded for Olderfjord, the individual Oribatei are generally found in lower densities than are the Collembola. Different Oribatei species are dominant, i.e. found in the highest density, in 4 of the 5 localities, whilst *Folsomia quadrioculata* among the Collembola is dominant in all 5 localities. The *Brachychthonius* spp. as a group are recorded as the most densely distributed species in the dry heath locality, but as the proportions of the 3 species present in the total is not known, it is not possible to show if the density of any one species approaches that of *Tectocepheus velatus*. Otherwise *T. velatus* is the most abundant species recorded, and is dominant in the dry heath and hay meadow localities, whilst *Oppia quadricarinata*

Table XIII. Mean numbers per m² of the Oribatei species in the five localities

Species	Dry heath	Hay meadow	Birchwood	Mineral soil	Wet heath
Eulohmannia ribiagi	331		33	7	
Nanhermannia nana	206		33		11
Hypochthonius rufulus				7	11
Brachychthonius spp.	3342		100	173	11
Synchthonius boschmai	1050	167	133	107	67
Platynothrus thori	28		333		11
P. peltifer	19	1167	33	133	22
Camisia lapponica	17		100		
C. spinifer	17				
C. segnis	161			7	22
Heminothrus paolianus	25		67		
Nothrus palustris	108	33		100	11
N. borussicus	56		100	120	156
Hermannia reticulata	11				
Caleremaeus monilepes	8			7	
Belba compta	194	33		27	
Damaeus tecticola			100		
Suctobelba perforata	178	133	33		
S. longirostris	125			7	22
Oppia translamellata	200	33	133	80	11
O. ornata	53	100			
O. quadricarinata	25		3100		
O. neerlandica	39			20	11
O. subpectinata	381	133	1767	7	100
Oribella castanea	8				
Ceratoppia sphaerica	6				
Scutovortex bidactylus				7	
Tectocepheus velatus	2736	1567	500	7	89
Carabodes marginatus	211	333		33	89
Liebstadia similis	56	767	500	13	
Oribatula venusta	228	67	433	187	78
Liacarus coracinus	72			167	67
Adoristes ovatus	178		300	13	
Chamobates borealis	6		400		
Ceratozetes thienemanni			200		
Melanozetes mollicomus	197			7	122
Neoribates aurantiacus	22				
Edwardzetes edwardsii	3				
Calyptozetes sarakensis	3			7	
Pelops spp.	19	33		20	33
Achipteria coleopterata	25	300			67
A. punctata	103				
A. italicus	242				
Oromurcia bicuspidata	19	1133	67		
Phthiracarus piger	117		100	40	67
P. borealis	286				89
Hoploderma striculum	31				22
Oribotritia loricata	75				

Table XIV. Mean density per m² of total number of the Oribatei and Collembola species in the five localities

	Dry heath	Wet heath	Birchwood	Mineral soil	Hay meadow
Oribatei	11214	1189	8567	1300	6000
Collembola	8933	1611	6333	1460	8033

is dominant in the birchwood and *Oribatula venusta* in the mineral soil locality. *Nothrus borussicus is* dominant in the wet heath locality, and *Pelops* spp. and *Ceratozetes thienemanni* are found at only slightly lower densities than in the other localities in which they occur.

Density of total Collembola and Oribatei

The mean densities of total Oribatei and Collembola per m² in the 5 localities in Table XIV, have been estimated on the basis of the total numbers of all species in all samples, irrespective of whether individual species were found in less than the total number of samples taken from each locality.

Table XIV shows that the densities of Oribatei and Collembola are similar in order in all localities, and that the Collembola were the more dense in the wet heath, mineral soil and hay meadow localities, whilst the Oribatei were denser in the dry heath and birchwood localities. The most productive localities in terms of the sum of the densities of the Oribatei and Collembola are in descending order of importance, the dry heath locality, with next the birchwood and hay meadow supporting similar densities, followed by similar densities in the wet heath and mineral soil localities but at a considerably lower level than in the previous two localities.

SUMMARY

The collection of 264 soil samples from 44 stations in the Olderfjord region of N Norway, and the use of a portable, modified Tullgren funnel extractor in the field are described. Fifty-three Oribatei species and 27 Collembola species are identified from the collected material, and constitute the first comprehensive species list of these two groups recovered by contemporary soil sampling techniques from this area of Norway. A description is given of the 5 localities into which the stations are grouped for the presentation of the data, according to the vegetative cover, soil type and moisture content.

The species are listed in systematic order, and the abundance and frequency of each species in all localities is noted. The lists of Oribatei and Collembola species are followed by a short account of the distribution of the species in habitats in other arctic countries. The density of each species per m² in all localities is estimated, and a comparative account of the relative densities of the species is given.

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